

1 Junk removal tool

2
3 The present invention relates to downhole tools for use
4 in removing junk from a well bore.

5
6 When drilling or completing a well bore, it is accepted
7 that a large amount of junk can be present within the
8 well bore. Such junk may comprise debris which are
9 generally considered to be small particles of such things
10 as metal shavings, chips, twists or curls, together with
11 particles of cement or scale which may have previously
12 adhered to the walls of the casing or liner. In this
13 group is included mud and other particulates found in
14 fluids circulated within the well bore. A further
15 category of junk is larger objects. These may include
16 portions of tools which have been discarded or been
17 broken within the well bore, or large sections of the
18 tubulars which have been cut away when portions of the
19 casing or liner have been milled or drilled, for example,
20 following casing milling or window cutting. Additionally
21 such junk can be produced after perforation.

22

1 A number of downhole tools have been developed for
2 collecting and retrieving junk found in a well bore.
3 This Application is primarily directed towards the
4 collection of large pieces of junk which cannot be
5 circulated out of the well bore.

6
7 Apparatus within a well bore designed to collect junk
8 primarily fall into two categories dependent upon the
9 location of the tool on a work string. The first
10 category relates to apparatus mounted at the bottom of
11 the work string. This apparatus collects all fluids and
12 materials within the well bore as fluids are circulated
13 up the well bore or as the tool is run into the well
14 bore. Such tools are typically referred to as junk
15 catchers and an example is that disclosed in US Patent
16 4,515,212 to Marathon. This tool has a collection of
17 petals arranged at the distal end of the work string. As
18 the tool is run into the well, the petals are forced
19 outward to the walls of the well bore where they act to
20 siphon all material through a single large port on the
21 longitudinal axis of the tool. When the tool is pulled
22 from the well the petals close thereby catching large
23 debris and pulling it from the well.

24
25 A significant disadvantage of this tool is that it must
26 be positioned at the end of a work string and thus is
27 typically used on a single run. To operate a dedicated
28 run merely for the purposes of clearing junk is both
29 time-consuming and expensive.

30
31 The second category of junk catchers can be mounted at
32 any position on a work string to allow the tool to be run
33 at the same time as other tools. A tool of this type is

1 disclosed in US Patent 6,176,311 to Baker Hughes
2 Incorporated. The tool has a wiper or scraper blade
3 arranged to prevent the fluid including the junk to pass
4 up the annulus between the tool and the well bore wall.
5 The fluid including the junk is forced into a port and
6 through a passage in the tool around the wiper. A filter
7 and a trap are positioned within the passage to catch the
8 junk, which is too large to pass through the filter.

9
10 Such tools have a disadvantage in that they can only
11 handle smaller pieces of junk, generally referred to as
12 debris. This is because the input port is sized to ensure
13 that a significant flow velocity is maintained to
14 circulate the fluid through the tool. As a result of this
15 narrow flow path, these tools generally include a by-pass
16 means which rupture to allow the fluid to escape when the
17 filter has been clogged with large debris. Thus, when
18 large debris is present the tool cannot function
19 correctly and, in fact, generally shuts down into a mode
20 that allows the fluid including the junk to by-pass the
21 tool. Additionally, junk tends to 'ball-up' at the
22 scrapers or wipers as the larger pieces of junk are swept
23 away from the inlet port up the annulus to become jammed
24 or located around the wiper blades.

25
26 It is an object of at least one embodiment of the present
27 invention to provide a downhole tool which can be
28 positioned anywhere on a work string and which can
29 collect large pieces of junk from within the well bore.

30

31 It is a further object of at least one embodiment of the
32 present invention to provide a downhole tool for
33 collecting or retrieving junk from a well bore which can

1 break up large pieces of junk so that they can be
2 collected and retrieved from the well bore.

3

4 According to a first aspect of the present invention,
5 there is provided a downhole tool for collecting and
6 retrieving junk from a well bore, the tool comprising a
7 cylindrical body attachable in a work string, a multi-
8 faceted surface arranged at an end of the body for
9 contacting with and breaking up junk and a plurality of
10 inlet ports through which the broken up junk passes into
11 a trap for collection.

12

13 Thus the tool is suitable for retrieving large pieces of
14 junk by breaking up the junk before collection. In
15 addition the plurality of input ports provide a large
16 access area to gather the broken junk into the trap.

17

18 Preferably the multi-faceted surface comprises a
19 plurality of projections, each projection being located
20 between adjacent inlet ports. More preferably the
21 projections include a plurality of tungsten carbide
22 coated surfaces to provide a grinding and/or milling
23 action to assist in breaking up the junk.

24

25 Preferably the tool includes a sleeve located around the
26 body, the sleeve including filter means for filtering
27 debris from fluid passing there through. Preferably also
28 the trap is provided in an annular space between the body
29 and the sleeve.

30

31 Preferably, the sleeve is detachable. This is arranged
32 so that when the tool is pulled from the hole the sleeve
33 can be removed and the junk can be disposed of.

1 Preferably, the inlet ports are arranged equidistantly
2 around the cylindrical body. Advantageously the ports are
3 perpendicular to a longitudinal axis of the tool so that
4 they are in the flow path. There may be four inlet ports.

5

6 Advantageously, each inlet port includes a valve to
7 prevent debris from falling back through the port once it
8 has entered. Preferably, the valves are flap valves.

9 These flap valves may be operated by a spring so that
10 they can be opened by fluid pressure but are urged to a
11 closed position.

12

13 Preferably, also, the tool includes a throat. The throat
14 may be a cylindrical body located adjacent to the
15 projections such that the diameter of the throat is
16 narrower than the diameter of the sleeve to allow a clear
17 access to the inlet ports.

18

19 Preferably the cylindrical body includes an axial bore to
20 permit fluid flow through the work string.

21

22 Preferably, also, the tool may include one or more
23 milling elements designed to be run in ahead of the
24 projections. Such an arrangement of additional milling
25 heads will tend to jet the junk towards the projections
26 and inlet ports of the tool.

27

28 According to a second aspect of the present invention,
29 there is provided a method of collecting and retrieving
30 junk within a well bore, comprising the steps:

31

- 1 (a) providing a multi-faceted contact surface on a work
2 string, the surface including a plurality of inlet
3 ports;
4 (b) breaking up large pieces of junk by contact with the
5 surface;
6 (c) collecting the broken-up junk through the inlet
7 ports; and
8 (d) storing the broken-up junk in a trap adjacent the
9 inlet ports.

10

11 Preferably, also, the method may further include the step
12 of providing a mill ahead of the surface and jet milled
13 junk from the mill towards the inlet ports.

14

15 Preferably, also, the method includes the step of
16 operating one or more valves at each inlet to prevent the
17 broken-up junk from exiting the trap.

18

19 An embodiment of the present invention will now be
20 described, by way of example only, with reference to the
21 accompanying figures of which:

22

- 23 - Figure 1 is a part cross-sectional view of a
24 downhole tool according to an embodiment of the
25 present invention;
26 - Figure 2 is a cross-sectional view of the downhole
27 tool of Figure 1 through section line A - A'; and
28 - Figure 3 is a downhole tool arranged on a work
29 string according to a further embodiment of the
30 present invention.

31

32 Reference is initially made to Figure 1 of the drawings,
33 which illustrates a downhole tool, generally indicated by

1 Reference Numeral 10, according to an embodiment of the
2 present invention. Tool 10 comprises a cylindrical body
3 12, having an upper end 14 and a lower end 16. It will
4 be appreciated that the reference to upper and lower can
5 be considered to relate to the position with respect to
6 the entry port of the well bore and thus the tool can be
7 used in a vertical, inclined or horizontal position as
8 required. At the upper end 14 of the tool 10 there is
9 located a box section 18 for connection of the tool to a
10 work string (not shown). At the lower end 16 there is a
11 pin section 20 for connection of the tool 10 to the lower
12 portion of the drill string (not shown). As will be
13 appreciated, the tool 10 can be inserted within a work
14 string. Body 12 includes an axial bore 22 providing an
15 access for fluid from the upper end 14 to the lower end
16 of the tool through a longitudinal passage.

17
18 Located around the body 12 is a sleeve 24. Sleeve 24
19 provides a thin annular wall 26, which includes ports 28,
20 30. Ports 28, 30 allow for the passage of fluid and
21 small debris to exit the tool 10 via the sleeve 26. As
22 can be seen from the Figure, ports 28 are larger than
23 ports 30 and are arranged towards the upper end 14 of the
24 tool.

25
26 Sleeve 24 is held in place via connecting screws 32 which
27 locate through a port 34 on the body 12. Screws 32 are
28 inserted into the port 34 and contact a conical spring 36
29 which assists in holding the screw 32 in place. When
30 mounted there is provided a trap 31 formed by an annular
31 space created between the body 12 and the sleeve wall 26.
32

1 Further ports 38 are arranged on the body 12 to provide a
2 substantially longitudinal exit path to expel fluid and
3 small debris from sleeve 24 outwith the body 12.

4
5 At the lower end of the sleeve 24 there are arranged
6 inlet ports 40. Each inlet port includes a flapper valve
7 41. Reference is now made to Figure 2 of the drawings,
8 which illustrates a cross-sectional view through the tool
9 of Figure 1 at the location of the inlet ports 40. Four
10 inlet ports 40A-D are arranged on the tool being
11 equidistantly spaced around the central bore 22. Each
12 inlet port 40A-D has a square cross-sectional area and
13 together the inlet ports 40A-D provide a substantial flow
14 path for junk into the tool. In the embodiment shown the
15 sleeve 24 has a diameter 8.25 inches and each inlet port
16 is a 2 inch x 2 inch square.

17
18 Valves 41 are flow assisted so that they open under flow
19 of material and are spring assisted to close.

20
21 Below the sleeve 24, is located a multi-faceted surface
22 42 on the body 12. Multi-faceted surface 42 comprises a
23 number of projections 44. In the embodiment shown there
24 are four projections, each located between adjacent inlet
25 ports 40. Thus, a channel 46 exists between neighbouring
26 projections to direct fluid and junk into the inlet ports
27 40.

28
29 Each projection 44 has a plurality of surfaces. One
30 surface is a transverse surface 48, substantially
31 perpendicular to the longitudinal axis of the tool. The
32 transverse surface 48 is arranged to contact the top of a
33 polished bore receptacle when the tool 10 is run into a

1 well bore. The surface 42 has a coating of tungsten
2 carbide so that the projections 44 can provide a milling
3 action when moved against a surface in the well bore e.g.
4 a polished bore receptacle or a large piece of junk.
5 Further, the projections include a raised surface 50
6 which assist in stabilising the tool within the well bore
7 and thus the projections 44 can be considered as
8 stabilisation blades.

9
10 Located below the projections 44 is a throat portion 52
11 of the tool 10. Throat portion 52 has a cylindrical body
12 with a diameter which is smaller than the diameter of the
13 sleeve 24. This provides a throat area for junk to be
14 swept into the channels 46 for entry through the inlet
15 ports 40.

16
17 In use the tool is connected to a work string via the box
18 section 18 and the pin section 16. The tool can be run
19 on the same trip as a pre-completion mechanical well bore
20 clean-up run or during a dedicated junk clean-out run.
21 The tool is run into the well bore and can be run to a
22 location where the tangential surface 48 lands on the
23 liner top of a polished bore receptacle and the clean-up
24 string is at TD. The tool can then be rotated to drill /
25 mill / polish any assemblies via rotation and
26 reciprocation as the multi-faceted surface 42 of the
27 projections 44 can contact the walls of the well bore.

28

29 When run into a well bore or alternatively when fluid is
30 circulated towards the tool, junk which is present in the
31 fluid will be forced passed the throat 52 and into the
32 large inlet ports 40 via the flapper valves 41. Due to
33 the flow against the flapper valves 41 they will open and

1 the junk laden fluid will enter the trap 31. The fluid
2 and small debris can exit through the ports 30, 28, 38
3 while the larger debris will become trapped and be
4 retained in the trap 31. Debris and junk which is larger
5 than the size of an inlet port 40 will be broken up by
6 the multi-faceted surface 42 on the projections 44.
7 Thus, large pieces of junk will be cut up and shattered
8 on the projections 42 and drawn in to the trap 31 through
9 the inlet ports 40. The size and location of the
10 projections 42 ensure that the junk is broken up into
11 pieces which can fit in the channels 46 and thus through
12 the inlet ports 40. The diameter of the throat 52
13 provides a maximum by-pass swallowing capacity also.

14
15 When work is complete and the tool is withdrawn from the
16 hole or remains stationary at a point in the well bore,
17 flapper valves 41 will automatically close via the spring
18 connections and the junk within the trap 31 is prevented
19 from falling out of the tool 10 as the tool is raised to
20 the surface, or when the flow is removed from an upward
21 direction in relation to the tool position.

22
23 As the inlet ports 40 are arranged uniformly around the
24 central bore 22, significant amounts of junk can be
25 collected within the tool and raised to the surface.

26
27 Reference is now made to Figure 3 of the drawings, which
28 illustrates the tool 10 including a mill 54 run ahead of
29 the tool 10 on a work string 56. The mill 54 is located
30 at a bottom end 16 of the tool 10. Like parts of the
31 tool to those of Figures 1 and 2 have been given the same
32 reference numeral. In this embodiment mill 54 may act as
33 a pilot mill to drill or mill up pieces of junk which can

1 then be jetted in through the channels 46 into ports 40
2 to the trap 31. This embodiment of the invention is
3 suitable to be run after casing milling or window cutting
4 operations to collect larger pieces of milling debris
5 that are sometimes produced during these operations and
6 could not be removed otherwise. The tool is also
7 suitable for running through already perforated pipe to
8 clean-up or remove perforating damage that restricts the
9 inner diameter of the well bore and retrieve any
10 perforation debris that cannot be circulated out of the
11 well bore. Further, the mill 54 can be used to act as a
12 tie back mill to clean out the inner diameter of a
13 polished bore receptacle when the projections 44 and, in
14 particular, the transverse surface 48 are landed on a
15 polished bore receptacle and used to dress off the
16 polished bore receptacle lip. Thus, it will be
17 appreciated that multi-faceted surface 42 acts as an
18 integral liner top dress mill on the tool 10.

19

20 The principal advantage of the present invention is that
21 it provides a tool capable of capturing large pieces of
22 junk or debris in a well bore by breaking up the junk and
23 then collecting the junk in a trap.

24

25 A further advantage of the present invention is that by
26 the use of a throat portion the junk laden fluid is
27 jetted in to the trap for collection. This results in a
28 tool which does not require to be rotated to create a
29 centrifugal force to drive fluid through the tool and can
30 therefore be operated by either being run into a well
31 bore or via circulation of fluid upwards through the
32 inlet ports 40.

33

1 A yet further advantage of the debris removal tool is
2 that it can be operated on any portion of a work string
3 and by virtue of the central bore 22 a separate fluid
4 path is created so that fluids can be taken up or
5 downhole separate from the fluid being attracted into the
6 trap 31. Thus the tool can be operated on a drill string.

7
8 Various modifications may be made to the invention herein
9 described without departing from the scope thereof. For
10 instance, the number, size and arrangement of the ports
11 40 can be adjusted as long as there remains a large input
12 surface into the trap to collect the larger pieces of
13 junk. Further, it will be appreciated that the tool can
14 be run with any other form of cleaning tool such as
15 brushes and scrapers as long as they do not obstruct the
16 passage of large junk being pushed towards the multi-
17 faceted surface 42 for milling and grinding to be broken-
18 up and thereby enter the ports 40.

19
20 Further, it will be appreciated that the ports on the
21 sleeve can be varied in size, depending on the debris
22 size which is acceptable within the well bore. If the
23 fluid is to be entirely screened, then a screen or wire
24 mesh filter may be appropriate.

25